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(71) Applicants (for all designated States except US): SIG TECHNOLOGY (NZ) LIMITED [NZ/NZ]; Flat 8, 31 Marriner Street, Sumner, Christchurch (NZ). SVAROG [RU/RU]; D 15/4 Flat 4, Shumilova Street, Moskva (RU).

(72) Inventors; and

(75) Inventors/Applicants (for US only): KELLY, Russell [NZ/NZ]; Flat 8, Marriner Street 31, Sumner, Christchurch (NZ). ULIANOV, Andrey Nikolaevich [RU/RU]; D 15/4 Flat 4, Shumilova Street, Moskva (RU).

(74) Agents: HAWKINS, Michael, Howard et al.; Baldwin Shelston Waters, NCR Building, 342 Lambton Quay, Wellington (NZ).

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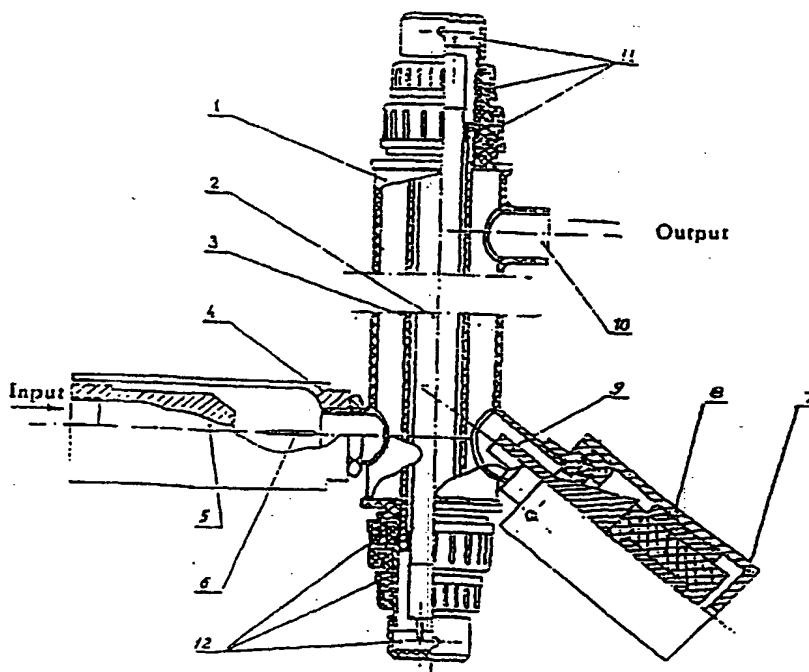
## Published

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(54) Title: REACTOR FOR CLEANING AND DISINFECTION OF AQUATIC MEDIA

## (57) Abstract

The reactor for cleaning and disinfection of aquatic media consists of a cylindrical casing with coaxially installed in it an ultra-violet tube fitted with a protective quartz jacket, an untreated water inlet, an ultra-sound vibration chamber and a treated water outlet. The reactor provides an advanced level of water cleaning from organic, inorganic, toxic agents and microflora at simultaneous reduction of energy consumption and the process duration, as well as prevention from precipitation on the surfaces of the reactor casing and the ultra-violet emission tube quartz jacket, due to subjecting of the water to ultra-sound and ultra-violet radiation in the same acoustic field.



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**REACTOR FOR CLEANING AND DISINFECTION OF AQUATIC MEDIA****Technical Field**

5    The invention protects the environment by the treatment and disinfection of industrial and domestic effluent, as well as other water sources such as surface water, from various types of contaminants up to the requirements of international standards.

**10    Background to the invention**

One of the most important problems of the end of 20<sup>th</sup> century is protection of the environment and water resources in particular. Discharges of insufficiently cleaned industrial and domestic effluent into natural water reservoirs, as well as 15 stormwater from city territories, industrial and agricultural enterprises, agricultural fields that were treated with pesticides, and a range of other factors result in the surface and other water sources containing not only contaminants of natural origin but also various chemical contaminants (such as pesticides, phenol, petroleum products, salts of heavy metals, etc.). At the same time, a vital necessity of 20 people is to have good quality potable water in sustainable quantities. Widely applied traditional technologies and units for cleaning and disinfection of water do not always provide sufficient removal of contaminants and the quality of the treated water does not always meet the requirements of international standards.

25    There is a known method of cleaning and disinfection of aquatic media, such as water, by an ultra-sound treatment with a subsequent ultra-violet treatment and filtration (see patent of the Russian Federation No 2092448, 1997). In this method, the chosen operating conditions for the ultra-sound treatment provide the formation of vapor-gas bubbles which, under the subsequent ultra-violet 30 treatment, result in the creation of free and peroxide radicals in the media that stimulate more intense photo-chemical reactions in the whole volume of the treated water. A drawback to this process is that the treated media is exposed to

ultra-sound and ultra-violet treatments in succession, which precludes from effective counteraction the precipitation of substances on the surface of the protective casing of the ultra-violet emitter. This results in a reduction in its transparency and, as a consequence, a reduction of the ultra-violet flow of the  
5 emitter and therefore a reduction of the process output in general.

There is a known unit for cleaning and disinfection of aquatic media (See: WO No 9601791, 1996) containing a shock chamber (in which the treated water is subjected to electrolysis/electric current for destroying cellular membranes and  
10 eliminating protective mechanisms of live organisms that would protect them from ultra-violet radiation), a cavitation chamber for the destruction of the remaining membranes of biological organisms, and an ultra-violet emission chamber. The drawbacks of this unit are that it operates in a pulse mode, and the treatment of biological organisms by alternating electric currents and electromagnetic fields,  
15 acoustic and ultra-violet emissions are not simultaneous, which results in a significantly higher energy consumption required for the treatment.

The most relevant, in a technical sense, to the present invention is a reactor made with a body or casing with an untreated water inlet and a treated water outlet  
20 sections (see EP No 0 655 417, 1995). An ultra-sound vibrator is located in the first section of the reactor; the second section of the reactor contains an ultra-violet emission tube (located axially relative to the ultra-sound vibrator) in a quartz jacket. The water delivered for treatment is subjected to ultra-sound vibration in the annular passage in the reactor inlet section, with a subsequent treatment by  
25 ultra-violet radiation in the second section of the reactor. The drawback of this unit is that the zones of ultra-sound and ultra-violet treatments are separated. This results in a significant energy consumption of ultra-sound during cleaning of the quartz jacket of the ultra-violet emitter. Besides, the ultra-sound treatment of the water in the narrow passage impedes the utilisation of all the advantages of the  
30 ultra-sound emitter as there are no zones of concentration of the ultra-sound field. This significantly extends the duration of the water treatment.

These methods enable effective to a degree effluent treatment for some toxic compounds and pathogenic microflora. The methods do however have certain disadvantages for example the use of chemicals can contribute to additional water contamination. There is also a need to construct bioreactors used to precipitate agents from the media. High capacity pulse radiation sources which have been used to produce the ultra-violet radiation result in a short service life for emitters and frequent replacements of gas discharge tubes are necessary.

An object of the invention is to provide an improved reactor for cleaning and disinfection of aquatic media providing an improvement in the level of cleaning from organic, inorganic, toxic contaminants and microflora, at a reduction in the process duration and its energy consumption.

Another object of the present invention is to provide a high level of water purification from contaminants to meet international standards while reducing energy consumption and providing a single method for various types of contaminants such as organic, inorganic, toxic contaminants and pathogenic microflora.

#### Disclosure of Invention

According to a first aspect of the invention the reactor for cleaning and disinfection of aquatic media includes a cylindrical casing with coaxially installed in it an ultra-violet tube fitted with a protective quartz or other protective material jacket, an untreated water inlet, an ultra-sound vibration chamber and a treated water outlet, that substantially differs [from other units] by the following:

the cylindrical casing is equipped with upper and lower protective seals, the untreated water inlet is located in the lower part of the cylindrical casing at an angle to its generating line and made as a cylindrical resonator which has installed a nozzle located alongside the water flow and a resonating plate; the ultra-sound vibration chamber is also located in the lower part of the cylindrical casing at an angle to its generating line and is fitted with an acoustic transducer and an ultra-sound concentrator.

The nozzle can be made in the shape of cotangential ellipsoidal conoid.

- 5 The angle between the axes of the untreated water inlet and the ultra-sound vibration chamber is not thought to be vertical and can be in plan no less than 90°, and the treated water outlet is located in the upper part of the cylindrical casing.
- 10 The reactor for cleaning and disinfection of aquatic media as described can be substantially different [from other units] by the following: the untreated water inlet and ultra-sound vibration chamber are located perpendicular to the cylindrical casing generating line and are displaced from each other in both vertical and horizontal planes.
- 15 The reactor for cleaning and disinfection of aquatic media as described can be substantially different [from other units] by the following: the untreated water inlet and the ultra-sound vibration chamber are located perpendicular to the cylindrical casing generating line and coaxial to each other.
- 20 The invention also prevents the precipitation of salts and oxides on the surface of the protective jacket of the ultra-violet emitter which reduces its transparency and on the surface of the reactor casing due to the fact that the reactor is made as a cylindrically shaped casing containing a coaxially located ultra-violet tube fitted with a protective quartz jacket; with top and bottom protective seals, the untreated water inlet being located in the bottom part of the cylindrical casing at an angle to the cylinder generating line and made as a cylindrical resonator, and being fitted with a water supply nozzle installed alongside the water flow and a resonating plate; an ultra-sound vibration chamber located in the lower part of the cylindrical casing at an angle to the cylinder generating line and fitted with an acoustical transducer and a concentrator of ultra-sound radiation; and a treated water outlet located in the top part of the cylindrical casing.
- 25
- 30

The angle between the axis of the untreated water inlet and axis of the ultra-sound vibrator is not thought to be critical and it can be no less than 90° in plan.

5 The water inlet for disinfection and the ultra-sound vibrator can be located perpendicular to the cylindrical casing generating line; and displaced from each other (skewed) in the vertical and horizontal planes as well as axially.

The nozzle can be the shape of a cotangential ellipsoidal conoid.

10 At an angle to its generating line as used herein means not an angle to the cylindrical casing axis but to a line which is parallel to the axis resting on the surface of the casing.

15 The position, in the proposed reactor, of the ultra-violet emitter fitted with the quartz jacket that is aggregated with the untreated water inlet made in a shape of the cylindrical resonator fitted with the water supply nozzle made in a cotangential ellipsoidal conoid shape, alongside the water flow, and the plate, and the ultra-sound vibrator, enables the applicants to conclude that the proposed technical solution complies with the criteria of "novelty" and "inventiveness 20 level".

The proposed reactor operates as follows.

25 The untreated water is delivered to the cylindrical resonator casing through the nozzle, which has its internal surface of a cotangential ellipsoidal conoid shape. As the water passes through the nozzle, it acquires the shape of the nozzle outlet, accelerates and flows around a flexible plate located in front of the nozzle, causing its vibration at a frequency that is close to the resonant frequency of the cylindrical resonator, i.e., a water jet is formed as it passes through the nozzle. 30 The water jet penetrates the cylindrical resonator chamber along its axis. This jet has a cross-section identical to the cross-section of the nozzle outlet. A powerful acoustic field is generated inside the resonator casing, causing formation of vapor-

gas cavities in the chamber and intense pulse whirls resulting in the breakage of bonds of proteins, fats, carbohydrates, and in damage of membranes of micro-organisms and their destruction at the cellular level, i.e., the formation of vapor-gas cavities in the chamber results in vapor-gas micro-bubbles and purely 5 cavitation formations being formed and distributed in the whole volume of the resonator and these are caused by whirls pulsing in the acoustic field of the resonator. The initial water treatment phase, results in elimination, partial destruction that disrupt functional activities of micro-organisms, spores, viruses that is of microflora and destruction of macromolecules and agglomerates take 10 place here. The formed jet is directed to the inside of the reactor, flows around the quartz protective jacket of the ultra-violet source and comes into the operational zone of the ultra-sound vibrator that has its frequency synchronised with the frequency of the cylindrical resonator. This intensifies the destruction processes due to pulsation and bursting of cavitation bubbles that result in the 15 formation of multitude volumetrically homogeneous zones with high reactive capabilities. This means a high energy concentration spot is created as a result of cavitation bubbles bursting, causing the formation, in this spot, of active radicals, peroxide agents i.e. agents enabling intense oxidation reactions. The completeness of destruction of organic agents due to oxidation in the ultra-sound 20 field is 70-80%. Shock waves occurring at bubble bursting lead to the destruction of macro-molecular bonds. The fragments of the macro-molecules acquire a charge that then assists in their intense oxidation by active radicals (in case of treatment of effluent or solutions, this assists in gluing the fragments of molecules and their precipitation out of solution). Thus, in the bottom part of the 25 casing, an intense cleaning process of water occurs, the water is being saturated with homogeneously distributed within its volume vapor-gas cavities and active radicals, and the water moves along the reactor towards the treated water outlet simultaneously mixing over and being subjected to ultra-violet radiation at the range of 180-400 nm. The radiation in the range of 180-200 nm results in the 30 formation of ozone in the vapor-gas bubbles/cavities. Synergy (combined simultaneous effect) of ultra-violet radiation, ozone and active radicals leads to additional oxidation of the remained contaminants and complete inactivation of

microflora. The cleaned and disinfected water is supplied, through the treated water outlet, to an end-user.

The positive effect of the application of the proposed unit lies in its advanced level of cleaning of aquatic media from organic, inorganic, toxic contaminants and microflora concurrently with a reduction of energy consumption and the process duration, as well as the prevention of precipitation on the reactor casing and the surface of the quartz tube jacket of the ultra-violet emitter due to subjecting of untreated water to ultra-sound and ultra-violet radiation in the same acoustic (common wave) field.

According to another aspect of the invention the invention provides liquid media containing contaminants is treated by ultrasound at a frequency of greater than approximately 25kHz and at 0.5 to 200 W/cm<sup>2</sup> followed by an ultra-violet radiation treatment.

The contaminants can be organic, inorganic, toxic contaminants and pathogenic microflora.

A number of sources of UV radiation can be used such as:

- (a) A pulsed source of radiation with a continuous spectrum of 180-300nm wavelength range at pulse durations of 10<sup>-6</sup> to 2x10<sup>-4</sup> seconds and a radiation density no less than 20kW/m<sup>2</sup> at any cross sectional point in the treated water volume.
- (b) A discharge source for continuous radiation in the 180 – 300nm wavelength range at a radiation density of no less than 50W/m<sup>2</sup> at any point in the cross section of the treated water volume.

After the ultra-violet treatment, harmless substances can be filtered using carbon or other types of filters.

According to another aspect of the invention there is provided a disinfection unit incorporating one or more ultrasonic cavitators in an inlet pipe, manifold or UV tube water inner or outer annulus of the unit for the express purpose of enhancing the exposure of target organisms to subsequent ultra-violet radiation.

5

The ultrasonic cavitators produce disinfectant chemicals.

- According to yet another aspect of the invention there is provided a method of purifying and disinfection of aquatic media that includes a prior ultra-sound treatment 10 with a following UV radiation treatment, that substantially differs (from other methods) by the following: that the ultra-sound treatment is conducted at a frequency of ultra-sound radiation exceeding about 25 kHz at a density of radiation of 0.05 – 200 W/cm<sup>2</sup>; and a pulse source of UV radiation of continuous spectrum is used for the UV treatment, in the 180-300 nm wavelength range; at a pulse duration 15 of  $10^{-4}$  to  $2 \times 10^{-4}$  sec, and pulse radiation density (at any cross-section of the treated water volume) no less than 20 kW/m<sup>2</sup>; alternatively a discharge source of continuous radiation can be used, in the 180 – 300 nm wavelength range at radiation density (at any cross-section of the treated water volume) no less than 50 W/m<sup>2</sup>.
- 20 The method in accordance with the yet another aspect above is different in that the water medium is subjected to filtration after the UV radiation treatment.

25

Various versions of the proposed reactor are shown in the drawings which are of examples of the invention.

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### Brief Description of Drawings:

30

Figure 1 depicts a vertical cross-section of a first example of reactor for cleaning and disinfection of aquatic media;

Figure 2 depicts the reactor (shown in Figure 1) in plan;

Figure 3 depicts a vertical cross section of a second example of reactor, where the untreated water inlet and the ultra-sound vibration chamber are located perpendicular to the generating line of the cylindrical casing and displaced from each other;

5

Figure 4 depicts the reactor (shown in Figure 3) in plan;

Figure 5 depicts a vertical cross-section of a third example of reactor, where the untreated water inlet and the ultra-sound vibration chamber are located perpendicular to the generating line of the cylindrical casing and coaxial with each 10 other;

Figure 6 shows a sectional view of an input channel of an example of disinfection preparation unit according to said another aspect of the invention; and

15

Figure 7 shows a sectional view of an in-tank or in-pipe or manifold disinfection preparation unit.

The first example of reactor for cleaning and disinfection of aquatic media 20 depicted in Figures 1 and 2 includes a cylindrical casing 1 with coaxially located in it a tube for ultra-sound emission 2 fitted with protective quartz jacket 3. The casing has an untreated water inlet located in the lower part of the cylindrical casing 1 at an angle to its generating line and made of cylindrically shaped resonator 4 fitted with supply nozzle 5 installed alongside the water flow (the 25 nozzle is the shape of a cotangential ellipsoidal conoid); and resonating plate 6. An ultra-sound vibration chamber 7 is located in the lower part of cylindrical casing 1 at an angle to its generating line and fitted with acoustic transducer 8 and ultra-sound emission concentrator 9. The casing 1 has a treated water outlet 10 and upper 11 and lower 12 protective seals. The angle between axes of the 30 untreated water inlet and ultra-sound vibration chamber in plan (depicted in Figure 2) is no less than 90°, and the treated water outlet 10 is located in the upper part of the cylindrical casing.

The geometric dimensions of ultra-sound emission concentrator 9, reactor casing 1 and protective quartz jacket 3 are chosen at a ratio which enables the maximum effectiveness of the processes of inactivation, destruction and oxidation on their surfaces and prevents precipitation of contaminants on their surfaces. This means  
5 that their dimensions are multiples of the length of the acoustic waves.

The location of the untreated water inlet at an angle to the cylindrical reactor casing generating line and the ultra-sound vibration chamber, results in the ultra-sound field action zone covering the whole volume of the reactor. The  
10 concentration of active radicals, ozone and peroxide agents builds up towards the reactor outlet, triggering more advanced cleaning of the water media even after the water has left the reactor. The location of the untreated water inlet at an angle is preferred because the ultra-sound field has a significant energy component alongside the reactor axis, and acoustic vibration forms turbulence and  
15 eddy-currents in the whole volume of the reactor, and in ultra-sound field knots the formation of active radicals takes place, etc.

In the second example shown in Figures 3 and 4, the axes of the untreated water inlet and the ultra-sound vibration chamber are displaced from each other along  
20 the vertical axis of the reactor casing 1. This provides intense mixing i.e. a conditionally vertical whirl is formed (the mixing of layers takes place around the horizontal axis) of the treated water layers along the variable cross-section of reactor operational volume during its passage through from the untreated water inlet to the treated water outlet. Similar parts to those incorporated in the first  
25 example are referenced by the same numerals. As a result of such a water treatment layout, in the lower part of the reactor casing 1 the water is intensely cleaned (the completeness of destruction of organic compositions and microflora within the ultra-sound field action zone reaches 80-90%).

30 Figure 4, which depicts Figure 3 in plan, shows that the axes of the untreated water inlet and the ultra-sound vibration chamber are displaced from each other in the horizontal plane. In this case, a tangential flow (twisting) rate around the

reactor vertical axis rises and the mixing intensity of the treated water layers grows, resulting in an enhanced efficiency of the water treatment at its low transparency and availability of suspension matters.

- 5 Simultaneous displacement of the untreated water inlet and ultra-sound vibration chamber axes from each other in both vertical and horizontal planes increases total flow turbidity that results in an increased water cleaning and disinfection efficiency.
- 10 In the third example reactor layout shown in Figure 5, the untreated water inlet and ultra-sound vibration chamber axes are located perpendicular to the cylindrical casing generating line and are axial, that means they represent an extension of each other and are separated by the emitter protective quartz jacket. Geometrical ratios in this structure are such that they intensify acoustic vibration, and the 15 effect of the cavitation treatment is maximised.

The most effective application of this layout is for treatment of effluent of low transparency and of high concentration of organic molecules, aromatic carbohydrates, sulphur agents, ammonia, arsine agents, phenol, etc.

- 20
- The inventive method uses a new approach to the UV stage water treatment. Unlike known methods using ultrasound radiation for the destruction of macro-molecules and agglomerates the present method uses special parameters of ultrasound radiation that provide the formation of vapor-gas bubbles in the treated water or liquid.

- 25
- The subsequent UV radiation applied to such bubbles leads to the formation of powerful oxidants (including free radicals, ozone and peroxide radicals) at significantly lower energy consumption levels. This in turn results in more intense photo-chemical ultra-violet reactions in the whole volume of the treated water.

As a result of such reactions an oxidation process takes place converting contaminant compounds into water, CO<sub>2</sub> or other neutral insoluble fractions usually trapped by filters.

- 5 The interaction between the bubbles and the contaminants is described in more detail below.

The cavities (cavitation bubbles) initially develop on non-uniformities or uneven surfaces which are responsible for carrying microflora and toxins and it is on these 10 non-uniform surfaces that the cavities first develop. These are often beyond the reach of normal UV radiation. When oxidants develop in the cavities by the action of the UV radiation at the boundary of the bubble they come in contact with the non-uniform surface where intense oxidising reactions take place leading to inactivation of toxins in microflora. In much the same way the inactivation occurs in the treated 15 water volume. As the overall surface area of the cavitation bubbles is large the effectiveness of the disinfection process significantly increases.

As the vapor and bubbles last for some time the oxidation process proceeds with the assistance of active free radicals formed in the bubbles even after UV radiation has 20 ceased.

To form cavitation bubbles of the required density it is necessary to have specific operating parameters for the operation of the ultra-sound chamber. The applicant has determined that at a frequency of 25kHz the resonance effects of gas-vapor bubbles 25 formed during cavitation can be observed. This fact can be corroborated by experiments utilising sonoluminescence. To sustain optimal spatial and temporal parameters of the bubbles it is necessary to initiate vibration mechanically with frequency multiples of the resonance frequency.

30 The density of ultra-sound radiation is chosen and is based on the following considerations. For the majority of processes it is recognised that a threshold intensity of ultra-sound amounts to 0.01 – 0.1W/cm<sup>2</sup>. The formation of gas-vapor

bubbles of a required firmness and quantity does not occur at densities less than 0.05W/cm<sup>2</sup>. Values of more than 2W/cm<sup>2</sup> influence harmfully live creatures and personnel. The inactivation can be effectively provided at lower levels of ultra-sound intensity within the specific range. However the ultrasound in the pre-disinfection unit 5 enables the application of intense ultrasonic energy which causes the size reduction and/or disintegration of particles larger than mono cellular and other living organisms such as viruses and sub-viral particles

Any ultra-sound exciter from the known range of devices (such as hydrodynamic, 10 piezoelectric or magnetostrictive) of low output with a one or two cascade concentrator of the ultra-sound can be used to provide the necessary frequency parameters.

One of the cascades can be made by the treated water/liquid itself using an 15 appropriate pipe design so that the water/liquid flows through the pipe being subjected to ultra-sound radiation.

The water/liquid treated in the ultra-sound chamber makes up a gas-liquid system (owing to a significant number of gas bubbles distributed in the whole water/liquid 20 volume) which arrives for UV treatment at the disinfection stage. Both pulse and/or discharge radiation sources of continuous spectrum in the 180-300 nm wavelength range can be used to perform this task. When a pulse radiation source is used, one sustains a density of radiation (in any cross-section of the water volume) of no less than 20 kW/cm<sup>2</sup> at a pulse duration of 10<sup>-6</sup> to 2 x 10<sup>-4</sup> seconds. When a discharge 25 source is used, a density of radiation of no less than 500 [50] W/cm<sup>2</sup> in any cross-section of the water volume shall be sustained. These parameters provide maximum cleaning results.

A high output pulse gas discharge tube, with a power source making pulses of the 30 discharge current and equipped with a system of discharge initiation, is used as a source of pulse UV radiation.

A metal-halogen and other sources of light, housed in a protective quartz or other suitable protective material casing and providing a required high level of radiation in the 180-300nm wavelength range, can be used as a discharge source of UV radiation.

5

The chosen parameters of operation of UV sources provide the following:

- To perform inactivation of virtually any organic and inorganic compounds as well as pathogenic microflora in water media to the requirements of international and local standards, at a significant reduction (up to 10-fold) in energy consumption for disinfectant, at all other factors being equal;
- To speed up oxidizing reactions in the treated water volume;
- To eliminate, salt and bio-build-up on quartz or other suitable protective material of pulse emitters and quartz or other suitable protective material protective casings of continuous UV radiation sources.
- 15 - To create prolonged (up to 10 min.) action of oxidants in vapor-gas bubble cavities after termination of UV radiation.

#### Example 1

Effluent containing contaminants in the quantities stated in Table 1 were directed to 20 the ultra-sound treatment chamber. Ultra-sound waves at 25 kHz frequency are activated by an ultra-sound exciter. From the driving oscillator, electrical fluctuations are fed to the exciter through an amplifier (in case of the use of a piezoelectric or magnetostrictive exciter). When a hydrodynamic exciter is used to produce ultra-sound waves, the activation of a resonant-emitter is made by the treated water 25 stream running onto an obstacle.

The density of radiation in the active zone is 0.05 W/cm<sup>2</sup> or more which is achieved at a rather low energy consumption from primary power sources (5 W-20 W at about 10% efficiency). A rise of ultra-sound intensity in the active zone occurs owing to: 30 two-cascade resonant exponential focusing cases, as well as an increase in energy of alternating electric signal supplied to the emitter. After a water sample treatment in the ultra-sound chamber (cavitated) for 1-2 seconds, the water becomes enriched

with cavitation gas-vapor bubbles of 0.1-0.5 mm diameter or less which have life duration of up to 10-15 minutes or more at standard conditions. After the ultra-sound treatment, such enriched water arrives into the UV chamber. One or several sources of pulse radiation of continuous spectrum in 180-300 nm wavelength range 5 are located along the lengthwise axis of the chamber. They are made of a tube transparent for UV radiation and filled with a mixture of inert gases or any other substance appropriate for the purpose. The chamber represents a case made of stainless steel or similar suitable manufacturing material such as plastics, of a cylindrical shape equipped with inlet and outlet sockets for the supply and discharge 10 of the treated water. The source of radiation operates in pulse-periodic mode at frequencies varying from 1Hz to 10Hz. The duration of a pulse is controlled by the alteration of operational capacity of the power source and is  $10^{-6}$  seconds. The density of radiation at any cross-section of the treated water volume is no less than 20 kW/m<sup>2</sup>. During its presence in the UV chamber, each volume of water is being 15 treated by three pulses of radiation (frequency – 3kHz [is this correct]). After the UV treatment, the water is additionally filtrated. The results of water purification are shown in Table 1.

#### Example 2

20 Water is treated in the ultra-sound chamber as in Example 1 but at the 50 kHz ultra-sound frequency and at 2 W/cm<sup>2</sup> density of radiation, then the water is treated with a pulse UV source at a pulse duration of  $2 \times 10^{-4}$  seconds at a minimum density of radiation of 100 kW/m<sup>2</sup> at pulse frequency of 1 Hz. The results of water purification are shown in Table 1.

25

#### Example 3

Water is treated in the ultra-sound chamber at operational parameters described in Example 1 (frequency 25 kHz, density of radiation of 0.05 W/cm<sup>2</sup>). Then the water is directed to the UV disinfection chamber which is equipped with a source of 30 radiation in the form of tube transparent for UV radiation and filled with a mixture of gases or steams. The water flows along a protective clear (for UV radiation) quartz casing, which is located around the gas discharge tube. This unit is located along the

lengthwise axis of the cylinder photo-reactor which is equipped with inlet and outlet sockets for the supply and discharge of the treated water. The density of radiation at any cross-section of the treated water volume is no less than  $50 \text{ W/m}^2$ . The duration of the ultra-sound treatment amounts to 1–2 seconds, duration of UV radiation amounts to 3 seconds. The results of water purification are shown in Table 2.

#### **Example 4**

Water is treated in accordance with the conditions stated in Example 2 (50 kHz, 2  $\text{W/cm}^2$ ), and then is treated by UV radiation by a discharge source described in 10 Example 3, at a density of radiation at any cross-section of the treated water volume of no less than  $100 \text{ W/m}^2$ . The results of water purification are shown in Table 2.

As can be seen from Tables 1 and 2, the method allows the applicant to achieve the following results:

- 15 - High level of water purification from colloids and suspended organic particles at a significantly lower energy consumption;
- Reduction of dissolved organic substances in the treated water to the ecologically safe levels;
- Completion of water disinfection for pathogenic microflora to the State Standards for drinking water;
- 20 - Provision of the output parameters for colour and smell to the required current standards.

#### **RESULTS OF PURIFICATION OF AQUATIC MEDIA IN EXAMPLES 1 AND 2**

**Table 1**

Contaminants in Untreated Water	Contents in Untreated Water	Contents After Treatment			
		Ultra-Sound	UV Radiation	Ultra-Sound	UV Radiation
		Example 1		Example 2	
Colloids, %					

-organic	1.8	1.5	0.1	1.2	0.02
-mineral	9.0	9.0	9.0	9.0	7.0
Suspended Particles, %					
-organic	7.5	6.2	0.8	5.5	0.15
-mineral	2.5	2.5	2.5	2.5	2.0
Dissolved Substances					
-organic	18	15	0.2	11	0.06
-hexane, mg/l	30	25	0.1	18	0.03
-carbophos, mg/l	40	32	0.12	24	0.06
Coli-Index in 1 litre	10 <sup>7</sup>	$6 \times 10^6$	1	$2 \times 10^6$	-
Colour, degree	50	15	5	7	3
Smell, marks	5	4	1	3	1

Rate of Purifying 3m<sup>3</sup>/hour

#### RESULTS OF PURIFICATION OF AQUATIC MEDIA IN EXAMPLES 3 AND 4

5

Table 2

Contaminants in Untreated Water	Contents in Untreated Water	Contents After Treatment			
		Ultra-Sound	UV Radiation	Ultra-Sound	UV Radiation
		Example 3		Example 4	
Colloids, %					
-organic	1.3	1.0	0.12	0.8	0.03
-mineral	6.0	6.0	6.0	6.0	4.8
Suspended Particles, %					
-organic	5.0	4.1	0.7	3.7	0.12
-mineral	2.0	2.0	2.0	2.0	2.0
Dissolved Substances					
-organic	15	12	0.5	10	0.06

-hexane, mg/l	20	18	0.32	14	0.025
-carbophos, mg/l	24	21	0.10	16	0.05
Coli-Index in 1 litre	$10^3$	$7 \times 10^3$	2	$2 \times 10^3$	-
Colour, degree	50	15	6	7	3
Smell, marks	5	4	1	3	1

Rate of purifying output 3m<sup>3</sup>/hour

5 The example shown in Figure 6 shows a cross section through an input channel 13 to a cavitation chamber 14 in which ultra-sonic cavitators 15 are incorporated. In the example there are shown four ultra-sonic cavitators. Each of the four cavitators 15 may be up to a 4kW unit.

10 In Figure 7 is shown the relative positions of three ultrasonic cavitators 16 situated relevant to a tank or input pipe or manifold 17 for a cavitation unit.

It is to be appreciated that as an alternative to the construction shown in Figures 6 and 7 the disinfection unit can include an additional ultra-sonic unit in the chamber of the cavitation unit near to its outlet.

15 Where in the foregoing description particular mechanical or other integers are described it is to be appreciated that their mechanical equivalents can be substituted as if they were individually set forth herein.

20 Thus by this invention there is provided a disinfection unit for the treatment of effluent and other water sources.

Particular examples of the invention have been described and it is envisaged that improvements and modifications can take place without departing from the scope 25 thereof.

**Industrial Application**

The proposed reactor can be used for cleaning of industrial and domestic effluent, as well as surface water sources from contaminants of various types and  
5 characteristics.

CLAIMS

1. A reactor for cleaning and disinfection of aquatic media includes a cylindrical casing with coaxially installed in it an ultra-violet tube fitted with a protective quartz or other protective material jacket, an untreated water inlet, an ultra-sound vibration chamber and a treated water outlet, that substantially differs [from other units] by the following:  
the cylindrical casing is equipped with upper and lower protective seals,  
the untreated water inlet is located in the lower part of the cylindrical casing at an angle to its generating line and made as a cylindrical resonator which has installed a nozzle located alongside the water flow and a resonating plate; the ultra-sound vibration chamber is also located in the lower part of the cylindrical casing at an angle to its generating line and is fitted with an acoustic transducer and an ultra-sound concentrator.
2. A reactor for cleaning and disinfection of aquatic media as claimed in claim 1 wherein the nozzle is made in the shape of cotangential ellipsoidal conoid.
3. A reactor for cleaning and disinfection of aquatic media as claimed in claim 1 or claim 2 wherein the angle between the axes of the untreated water inlet and the ultra-sound vibration chamber is not vertical and in plan is no less than 90°, and the treated water outlet is located in the upper part of the cylindrical casing.
4. A reactor for cleaning and disinfection of aquatic media as claimed in claim 1 or claim 2 wherein the untreated water inlet and ultra-sound vibration chamber are located perpendicular to the cylindrical casing generating line and are displaced from each other in both vertical and horizontal planes.

5. A reactor for cleaning and disinfection of aquatic media as claimed in claim 1 or claim 2 wherein the untreated water inlet and the ultra-sound vibration chamber are located perpendicular to the cylindrical casing generating line and coaxial to each other.
10. A reactor for cleaning and disinfection of aquatic media as claimed in any one of the preceding claims which prevents the precipitation of salts and oxides on the surface of the protective jacket of the ultra-violet emitter and on the surface of the reactor casing due to the fact that the reactor is made as a cylindrically shaped casing.
15. A reactor for cleaning and disinfection of aquatic media as claimed in claim 6 wherein the casing contains a coaxially located ultra-violet tube fitted with a protective quartz jacket; and is closed with top and bottom protective seals, the untreated water inlet being located in the bottom part of the cylindrical casing at an angle to the cylinder generating line and made as a cylindrical resonator, and being fitted with a water supply nozzle installed alongside the water flow and a resonating plate.
20. 8. A reactor for cleaning and disinfection of aquatic media as claimed in claim 7 with an ultra-sound vibration chamber located in the lower part of the cylindrical casing at an angle to the cylinder generating line and fitted with an acoustical transducer and a concentrator of ultra-sound radiation.
25. 9. A reactor for cleaning and disinfection of aquatic media as claimed in claims 6 to 8 wherein a treated water outlet is located in the top part of the cylindrical casing.
30. 10. A reactor for cleaning and disinfection of aquatic media as claimed in any one of claims 6 to 9 wherein the angle between the axis of the untreated water inlet and axis of the ultra-sound vibrator is no less than 90° in plan.

11. A reactor for cleaning and disinfection of aquatic media as claimed in any one of claims 6 to 9 wherein the water inlet for disinfection and the ultra-sound vibrator is located perpendicular to the cylindrical casing generating line, and displaced from each other (skewed) in the vertical and horizontal planes as well as axially.  
5
12. A reactor for cleaning and disinfection of aquatic media substantially as herein described with reference to the accompanying drawings.
- 10 13. A reactor for cleaning and disinfection of aquatic media wherein liquid media containing contaminants is treated by ultrasound at a frequency of greater than approximately 25kHz and at 0.5 to 200 W/cm<sup>2</sup> followed by an ultra-violet radiation treatment.
- 15 14. A reactor for cleaning and disinfection of aquatic media as claimed in claim 13 wherein the contaminants are organic, inorganic, toxic contaminants and pathogenic microflora.
- 20 15. A reactor for cleaning and disinfection of aquatic media as claimed in claim 13 or claim 14 wherein the source of UV radiation is either:
  - (a) a pulsed source of radiation with a continuous spectrum of 180-300nm wavelength range at pulse durations of 10<sup>-6</sup> to 2x10<sup>-4</sup> seconds and a radiation density no less than 20kW/m<sup>2</sup> at any cross sectional point in the treated water volume; or
  - 25 (b) a discharge source for continuous radiation in the 180 – 300nm wavelength range at a radiation density of no less than 50W/m<sup>2</sup> at any point in the cross section of the treated water volume.
- 30 16. A disinfection unit incorporating one or more ultrasonic cavitators in an inlet pipe, manifold or UV tube water inner or outer annulus of the unit for the express purpose of enhancing the exposure of target organisms to subsequent ultra-violet radiation.

17. A disinfection unit as claimed in claim 16 wherein the ultrasonic cavitators produce disinfectant chemicals.
18. A disinfection unit substantially as herein described with reference to Figures 5 and 7 of the drawings.
19. A method of purifying and disinfection of aquatic media that includes a prior ultra-sound treatment with a following UV radiation treatment, that substantially differs (from other methods) by the following: that the ultra-sound treatment is conducted at a frequency of ultra-sound radiation exceeding about 25 kHz at a density of radiation of 0.05 – 200 W/cm<sup>2</sup>; and a pulse source of UV radiation of continuous spectrum is used for the UV treatment, in the 180-300 nm wavelength range; at a pulse duration of 10<sup>-4</sup> to 10 2 x 10<sup>-4</sup> sec, and pulse radiation density (at any cross-section of the treated water volume) no less than 20 kW/m<sup>2</sup>; alternatively a discharge source of 15 continuous radiation can be used; in the 180 – 300 nm wavelength range at radiation density (at any cross-section of the treated water volume) no less than 50 W/m<sup>2</sup>.
20. A method as claimed in claim 19 wherein the water medium is subjected to filtration after the UV radiation treatment.
21. A method of purifying and disinfection of aquatic media substantially as herein described with reference to the examples.

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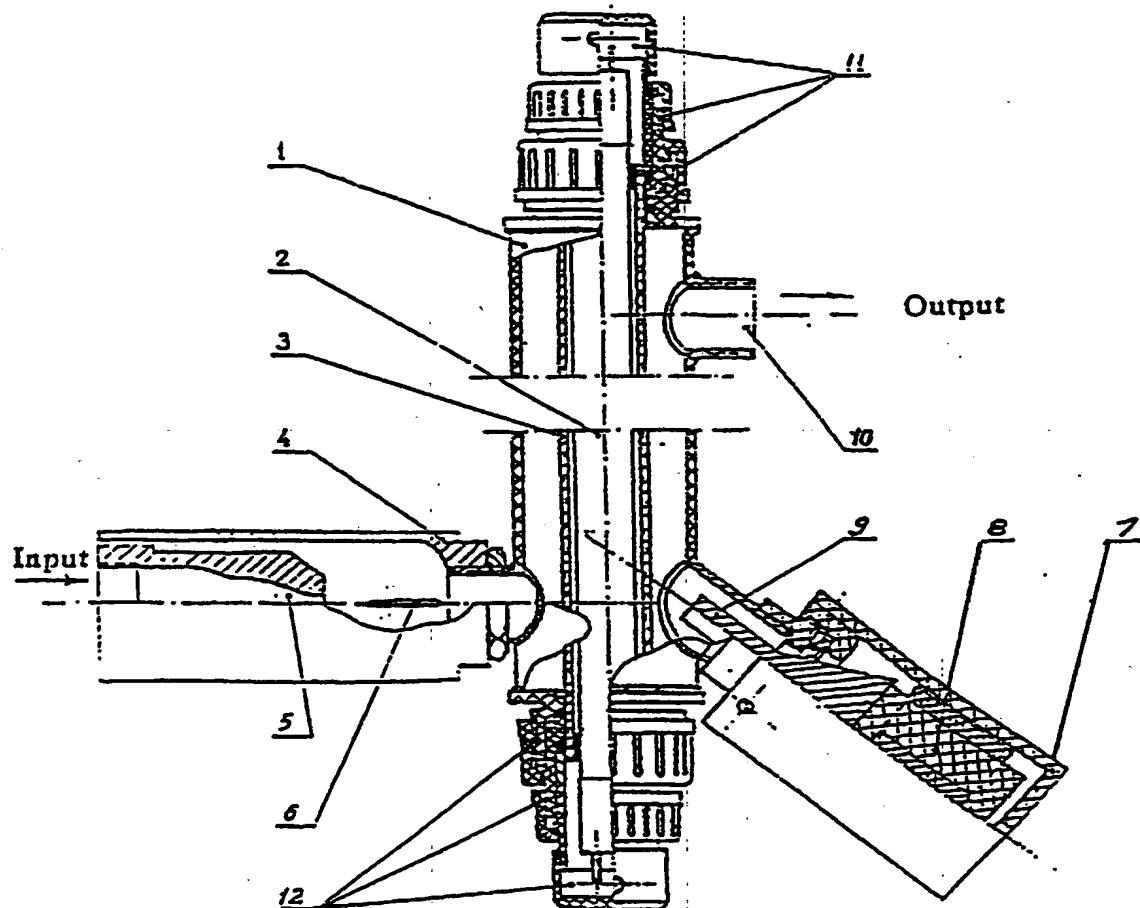


Fig. 1

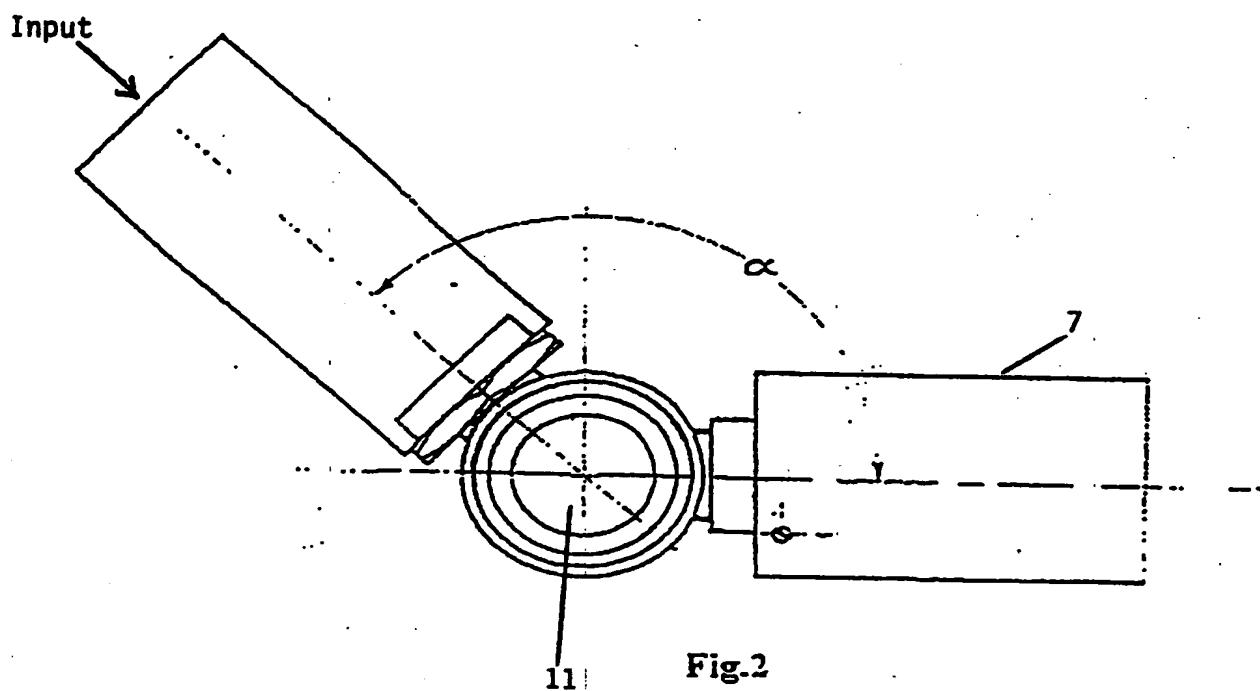


Fig.2

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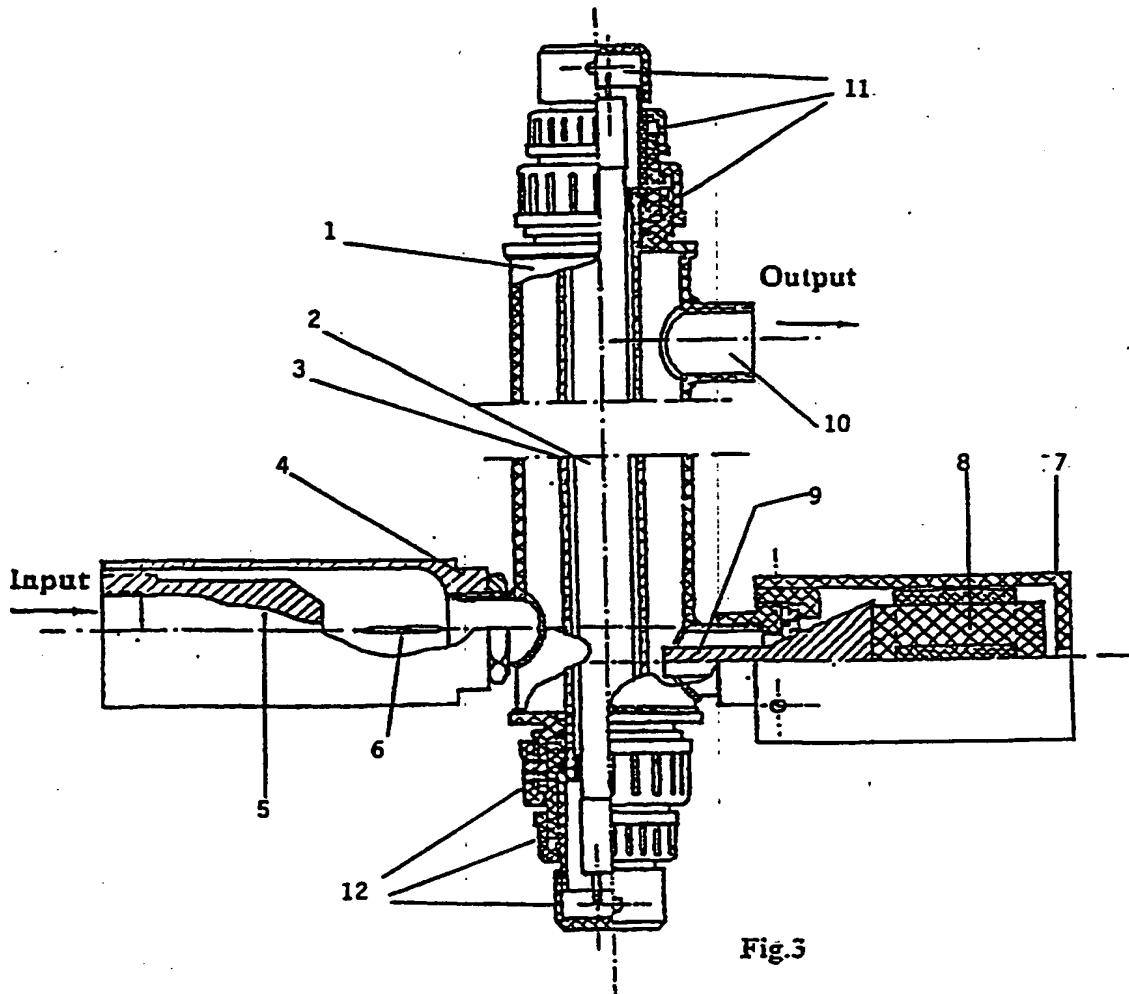


Fig.3

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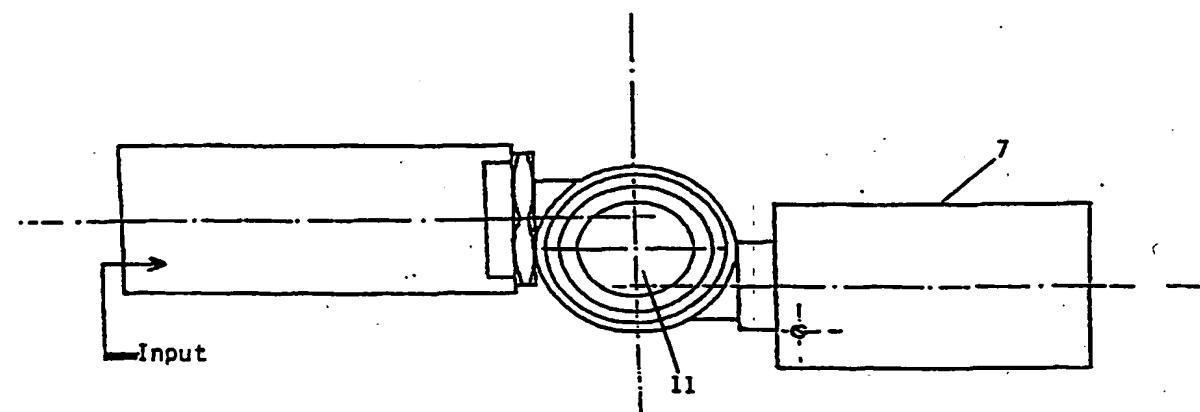


Fig.4

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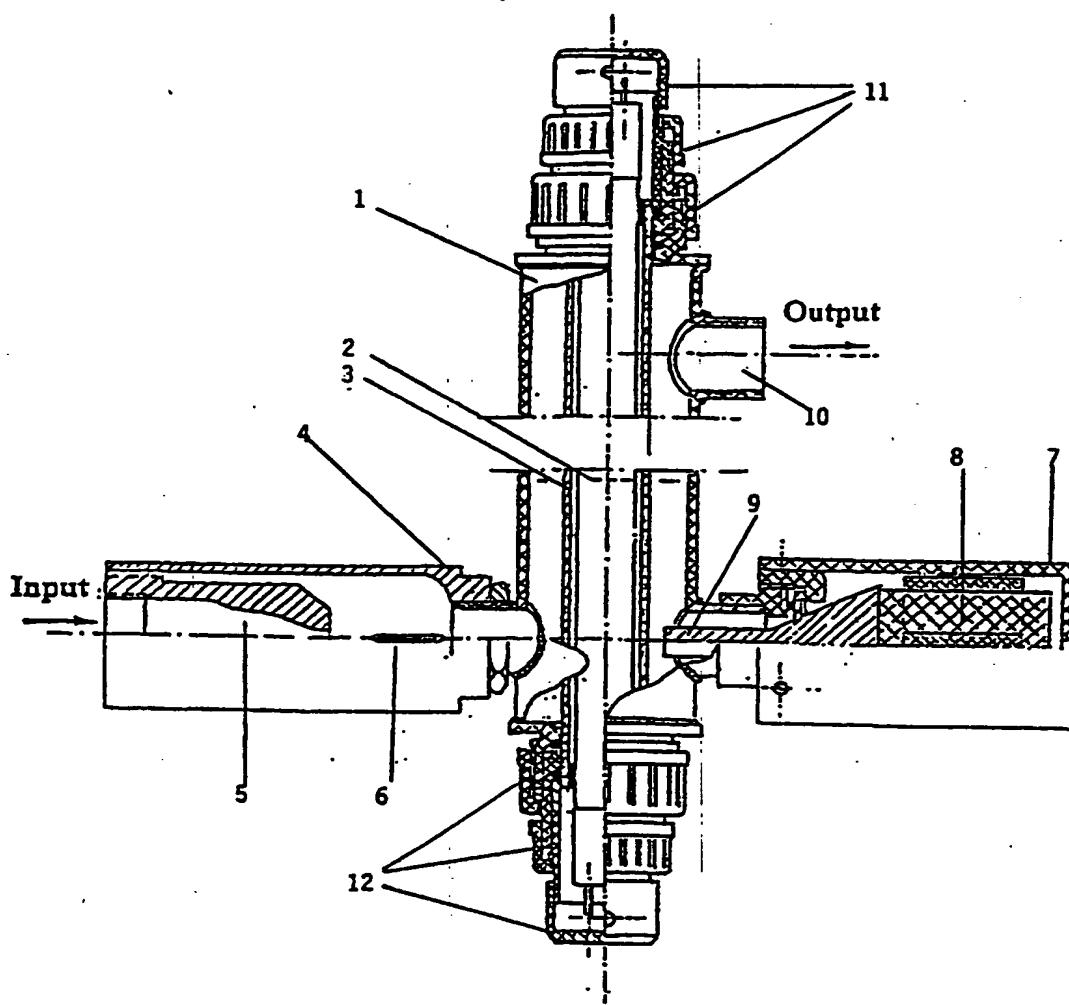


Fig.5

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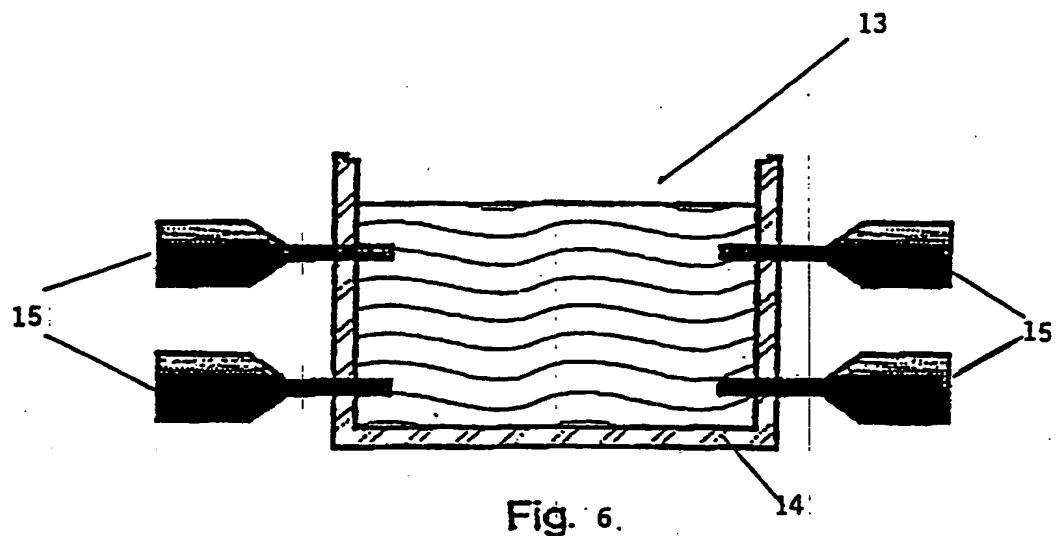


Fig. 6.

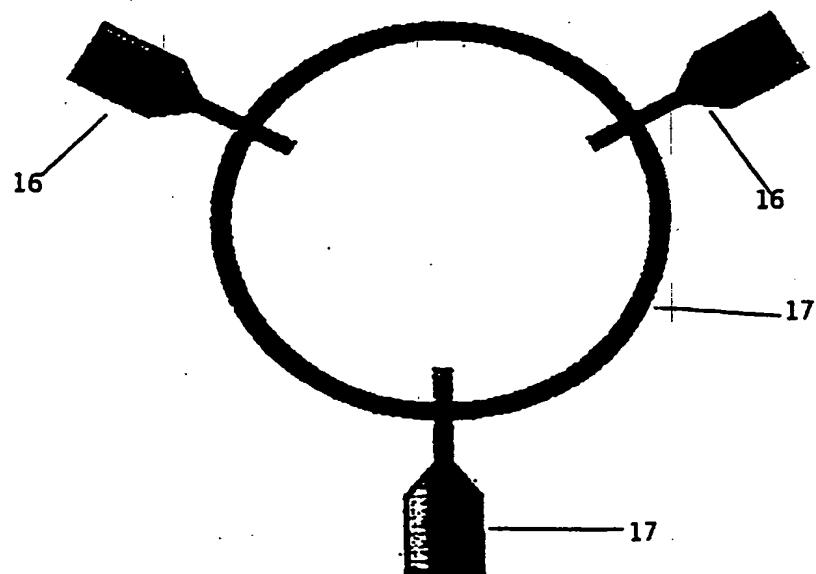


Fig. 7

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/NZ 00/00041

## A. CLASSIFICATION OF SUBJECT MATTER

Int Cl<sup>7</sup>: C02F 1/32, 1/36

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
C02F 1/32, 1/36, C02B 1/80, 1/00, C02C 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
WPAT, JAPIO (IPC plus keywords)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2442218 A (Hyco et Aulas) 20 June 1980. See pages 1-6, figure.	1, 13, 16
X	DE 3739979 A (Katadyn) 8 June 1989. See cols 1 & 2, figure	1, 16
X	EP 655417 A (Grunbeck) 31 May 1995. See abstract, figures	1-16

Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents:	
"A"	Document defining the general state of the art which is not considered to be of particular relevance
"E"	earlier application or patent but published on or after the international filing date
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O"	document referring to an oral disclosure, use, exhibition or other means
"P"	document published prior to the international filing date but later than the priority date claimed
"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&"	document member of the same patent family

Date of the actual completion of the international search

16 June 2000

Date of mailing of the international search report

29 JUN 2000

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE  
PO BOX 200  
WODEN ACT 2606 AUSTRALIA  
E-mail address: pct@ipaaustralia.gov.au  
Facsimile No.: (02) 6283 3929

Authorized officer

JAMES DZIEDZIC  
Telephone No.: (02) 6283 2495

**INTERNATIONAL SEARCH REPORT**International application No.  
PCT/NZ 00/00041

<b>C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to claim No.</b>
X	US 4752401 A (Bodenstein) 21 June 1988. See claims & figures	1, 16
X	Derwent Abstract Accession No 98-566435/48, Class D15, K07, RU 2109688 A (Railyan) 27 April 1998. See abstract & figure.	1, 16
X	Derwent Abstract Accession No 98-249566/22, class D15, RU2092448 A (Ulyanov) 10 October 19097. See abstract.	13, 19
X	Derwent Abstract Accession No 93-393718/49, class X25, SU 1776639 A (Khark Municipal) 23 November 1992. See abstract.	1, 16
X	Derwent Abstract Accession No 92-398738/48, Class X25, WO 9219550 A (Rotor) & WO9219550 A 12 November 1992	13, 16
X	Derwent Abstract Accession No 90-093906/13, Class P34, J02043984 A (Yamagata) 14 February 1990. See abstract.	1, 16
X	Derwent Abstract Accession No 85-118729/20 Class D15, K07, J60058291 A, (JGC Corp) 4 April 1985. See abstract.	1, 16

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
**PCT/NZ 00/00041**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member
EP 655417	DE 4340406

**END OF ANNEX**